Multi-Decadal High-Resolution Hydrologic Modeling of The Arkansas-Red River Basin

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RESEARCH OBJECTIVES

This follow-on study of the DOE Water Cycle Pilot (Miller et al. 2005) evaluates the contrast between fine spatial scales at which heterogeneity is significant (1 km and finer) and coarser scales at which climate simulations are generated. The objectives of this study are to identify physiographic and climatic controls on the spatial variability of soil moisture; to develop new subgrid parameterizations for soil moisture during wet and dry conditions; to examine the spatial scaling properties of soil moisture; and to perform a statistical analysis of the teleconnections between climatic variables and land surface states and processes, such as soil moisture and evapotranspiration.

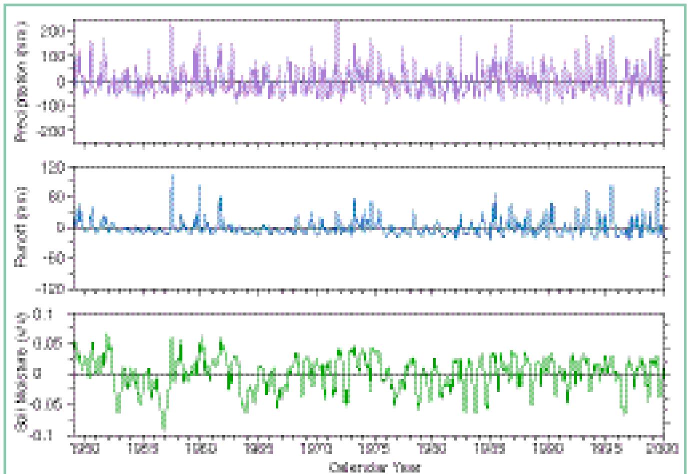

Figure 1. Time series of monthly anomalies of precipitation, runoff, and soil water storage. Notice that while runoff amplifies positive anomalies in precipitation, soil water storage amplifies negative anomalies.

APPROACH

We generated a 51-year simulation of water and energy fluxes over the Arkansas-Red River Basin, using the fully distributed land surface model, TOPLATS, at fine temporal (hourly) and spatial (1 sq. km) resolutions, to bridge the gap between traditional hydrologic modeling and regional land-surface modeling. We focused on the accuracy of streamflow simulations at the sub-basin scale, with physically based descriptions of heat and water exchange at the land-atmosphere interface, because sub-basin scale biases may grow nonlinearly over time, leading to larger basin-scale biases.

ACCOMPLISHMENTS

The surface runoff did not show a distinct shift of the east-west gradient during the summer months as observed for precipitation. The variability of interannual basin-averaged precipitation varied strongly and decreased during the simulation period. Results indicate that precipitation variability amplified in the runoff, but decreased with time. Both basin-averaged precipitation and surface runoff increased during the simulation period, on average, at different rates, suggesting that evapotranspiration increased. This conclusion is supported by analysis of evapotranspiration at the sub-basin scale and observed discharge. Results agree with mounting evidence of an accelerating hydrologic cycle over the conterminous United States. Monthly precipitation and runoff have also increased over the simulation period, except during May and July. It was also found that runoff amplifies positive precipitation anomalies, while soil water storage amplifies negative anomalies.

SIGNIFICANCE OF FINDINGS

The study enhances understanding of the correlation between mean-monthly, seasonal, and annual variations in surface energy fluxes, soil moisture, and stream flow and large-scale atmospheric patterns. The results of this analysis will help clarify the sources of long-term hydrologic variability at regional scales.

RELATED PUBLICATION

Sharif, H. O., W. T. Crow, N. L. Miller, and E. F. Wood, Multi-decadal high-resolution land surface modeling study in the Southern Great Plains. J. of Hydrometeorology (submitted), 2005.

Miller, N.L., A.W. King, A. Millard, E.P. Springer, M.L. Wesley, K. Bashford, J. Conrad, K. Costigan, P.N. Foster, H.K. Gibbs, J. Jin, J. Klazura, B.M. Lesht, M.V. Machavaram, F. Pan, D.L. Song, D. Troyan, and R.A. Washington-Allen, The DOE Water Cycle Pilot Study. Bulletin of the American Meteorological Society, 86 (3), 359-374, 2005. Berkeley Lab Report LBNL-53826.

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